Lecture 4:
Cohort fertility

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Cohort fertility

- Generational renewal
- Age-specific fertility
- *ASFRs* and the *NRR*
- Cohort parity
- Natural fertility

Generational renewal

- We have covered mainly the beginning and ending of lifelines on a Lexis diagram
  - The start of life when one is born into a cohort
  - The end of life when one takes one's exit by dying

- On the Lexis diagrams, we have been marking nothing at all along the lifeline, as if nothing happened in between birth and death
  - In between, among other things, comes childbearing

Example of cohort fertility

- Example of a cohort of women, focusing on their daughters

- Sample of 10 women drawn from the 5,994,000 women born into the 5-year birth cohort born between 1930 and 1935 in the United States
  - One of these women died 4 months after birth
  - Another woman died at the age of 30

Fertility in the Lexis diagram

- The remaining eight women survived through to the end of the ages of childbearing
  - Two of them had two daughters each
  - Four of them had a single daughter
  - Two of them had no daughters

- Each of these births is a droplet along the mother’s lifeline

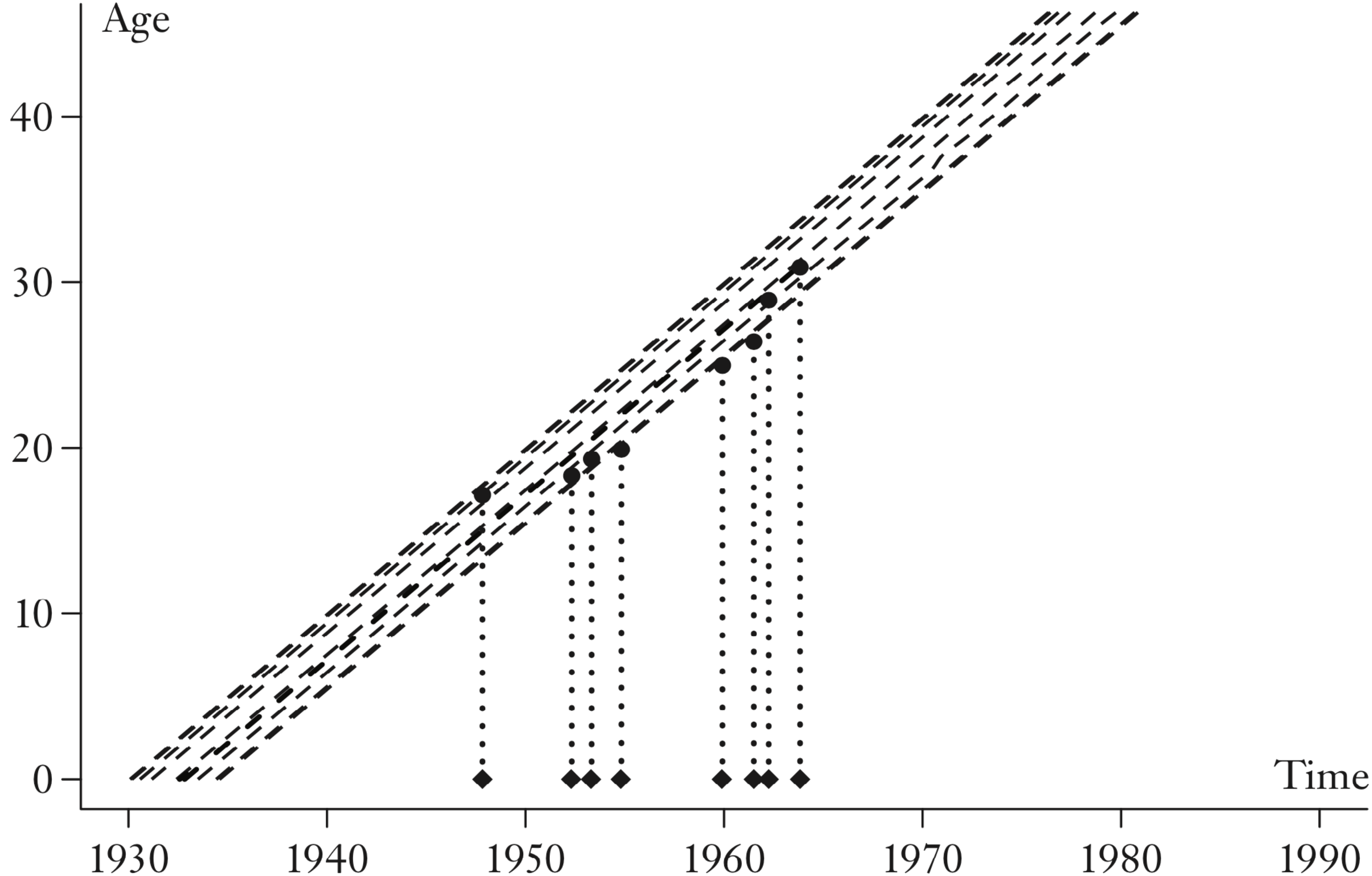


Figure 4.1 Cohort fertility on a Lexis diagram

Process of generational renewal

- The Lexis diagram shows a process of generational renewal
  - First generation: cohort of women
  - Second generation: their daughters
  - Third generation: daughters’ daughters
- The ratio of the total number of daughters born by cohort members to the initial number of women in the cohort is a generational replacement ratio
  - This is the ratio of the size of the second generation to the first
  - Net Reproduction Ratio
  - Less precisely but more commonly, Net Reproduction Rate (*NRR*)

Be precise with name

- The name “Net Reproduction Rate” is more common than “Net Reproduction Ratio”
  - But to call the *NRR* a “rate” is a misnomer
  - A rate in demography is a value per unit of time, per year, per month, per decade
- The *NRR* is a pure ratio
  - Daughters divided by mothers
  - Mothers (denominator) do not have a chance to experience the event (move to numerator)
  - *NRR* is not expressed in units of time
- Other names used are “Generational Replacement Ratio” and “Net Reproductive Ratio”

NRR formula

- Historical data usually has numbers of babies rather than numbers of daughters
- We need to convert from babies of both sexes to daughters when we calculate an *NRR*
- The conversion factor is the fraction female at birth (f_{fab})
- Cohort of U.S. women born in 1934
  - They generated the peak of the Baby Boom
  - 1,054,933 women
  - 3,231,638 babies
  - 1,576,094 daughters

$$NRR = \frac{(3{,}231{,}638) * (0.4877)}{1{,}054{,}933} = 1.494$$

$$NRR = 1{,}576{,}094 \,/\, 1{,}054{,}933 = 1.494$$

NRR and population growth

- In a closed population, if cohort after cohort each has a Net Reproduction Ratio greater than 1
  - Then we expect each generation to be larger than the next
  - So, we expect a growing population
- If cohorts have *NRR* values equal to 1 over the course of many generations
  - Then we expect a stationary population
- If cohorts all have *NRR* values less than 1
  - Then we expect a contracting population

NRR calculation

- When totals for cohorts and their babies are available, the calculation of the *NRR* is elementary
  1. Number of babies born by the cohort
  2. Fraction female at birth (f_{fab})
  3. Number of women in the cohort
- We multiply (1) and (2) and divide by (3) to obtain the *NRR*

$$NRR = \frac{(\text{births to women in cohort})(f_{\text{fab}})}{\text{women in cohort}}$$

- In the next example, we see
  - *NRR* rising up to the 1934 cohort of Baby Boom mothers
  - *NRR* falling back below 1 as the Baby Boom gave way to a “Baby Lull”

Table 4.1 Generation sizes and the *NRR*

Cohort	Babies	f_{fab}	Cohort Size	*NRR*
1910	2,665,122	0.4871	1,353,682	0.959
1922	3,579,318	0.4866	1,408,021	1.237
1934	3,231,638	0.4877	1,054,933	1.494
1947	3,788,342	0.4871	1,884,884	0.979

Default value for female birth

- Frequently, the fraction female at birth is not published
  - We need a default value
  - This fraction is generally a little less than one-half
- Current studies suggest that nearly equal numbers of boys and girls are conceived
  - Slightly more male fetuses normally survive to birth
  - The default value adopted is $f_{fab} = 0.4886$
  - But when the true value is known, we always use it

Default fraction and sex ratio

- The advantage of using a special number like 0.4886 for our default rather than a common number (0.5000) is ease of recognition
  - The number 0.4886 occurs nowhere in formulas except as f_{fab}, whereas 0.5000 may occur in formulas for many other reasons
  - 0.4886 was the fraction in America at the time of textbook publication
- Demographers often quote sex ratios on a percentage basis in place of fractions female
  - The sex ratio at birth implied by the default fraction is
  - $100 * (0.5114) / (0.4886) = 104.67$

NRR is an input-output ratio

- **Input:** potential future mothers starting life in a cohort
- **Output:** baby daughters in the next generation
- The essential feature of an input-output ratio is that input must be measured in the same units as output

Same unit for input and output

- Since we are measuring input as a count of females, we need to measure output as a count of females
  - We have women as input, so we need daughters as output, not sons plus daughters
- Furthermore, we have newborn women as input
  - We count the size of the cohort at birth, not at some later age
  - We count newborn daughters as output, not daughters at some later age

Considering mortality

- Mortality comes into the *NRR*, but only once, through the mortality of potential mothers
  - Some members of a cohort die before beginning or completing childbearing
  - Their deaths reduce the eventual total number of daughters and so affect the *NRR*

- *NRR* is a measure of reproduction net of the effects of mortality
  - That is, remaining reproduction after mortality has been taken into account

Analogy with income

- Mortality diminishes a cohort's production of offspring just as taxes diminish a person's spendable income

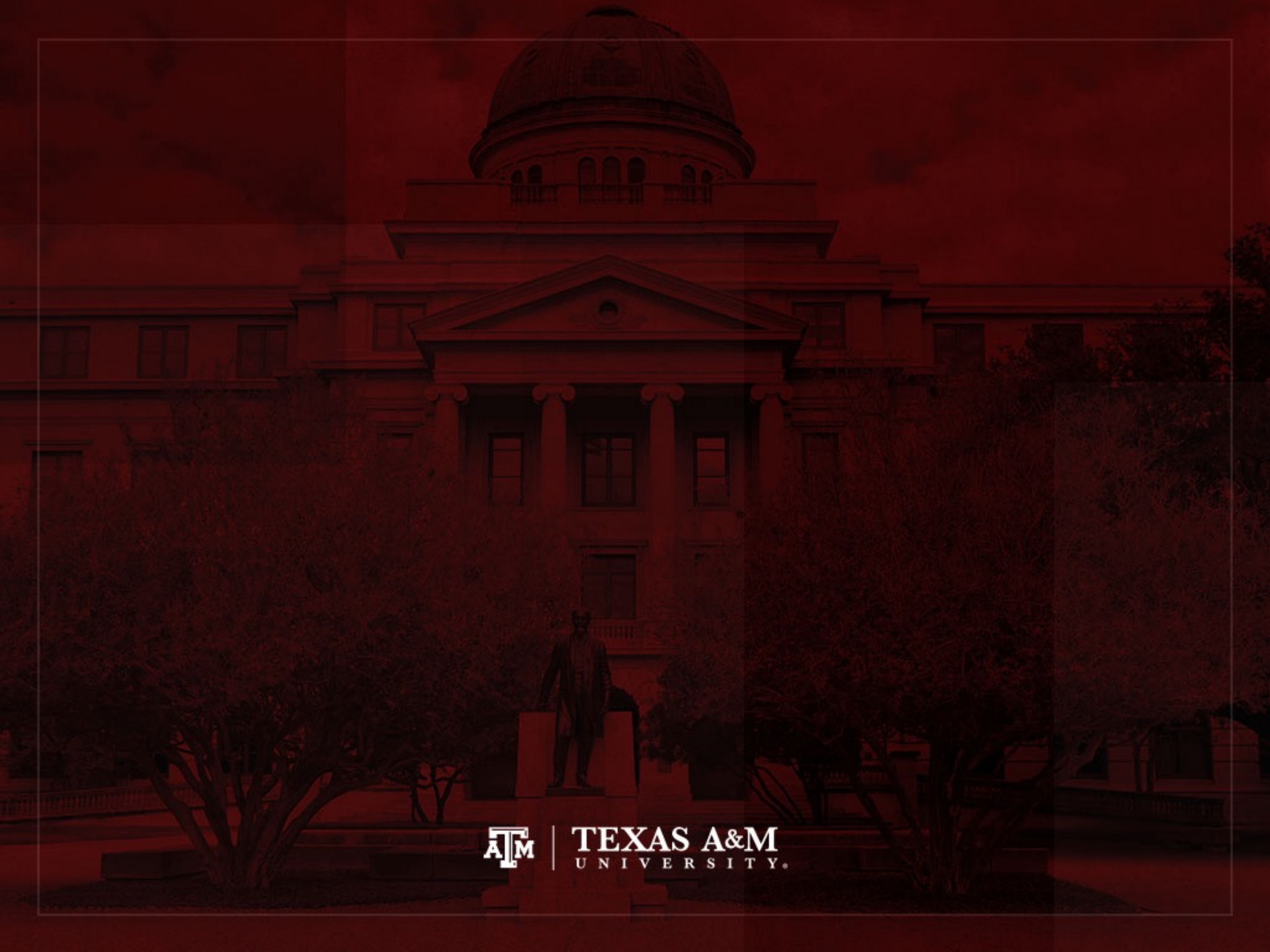
- The Net Reproduction Ratio is like a person's net income after taxes

- There is also a Gross Reproduction Ratio
  - It is like gross, pre-tax income and excludes losses due to mortality (does not consider mortality)

Formal definition of *NRR*

- The Net Reproduction Ratio is the shining measure of demography
  - The word “net” derives from a Latin root meaning “shining”
  - It is one of the most important quantities demographers study

- The Net Reproduction Ratio (*NRR*) is
  - The number of daughters per newborn prospective mother who may or may not survive to and through childbearing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Age-specific fertility

- The presentation of the *NRR* as a ratio of generation sizes (daughters divided by mothers) is easy to understand conceptually

- In practice, however, the common method for calculating the *NRR* makes use of age-specific fertility rates

Age-specific fertility and *CBR*

- Age-specific fertility rate is like a Crude Birth Rate
  - It has babies in the numerator and person-years in the denominator

- But it is different than the Crude Birth Rate
  - The babies are only the babies born to women in a particular age range
  - The person-years are only person-years lived by the women within that age range

Restrictions on person-years

- There are two restrictions on the person-years
- They have to be lived within the particular range of ages
- They have to be lived by women, not (as with the Crude Birth Rate) by men and women

Cohort age-specific fertility rate

- We take an age interval from x to $x+n$
- For a cohort age-specific fertility rate (${}_nf_x$)
  - We divide babies of both sexes born to women in the cohort while the women are between ages x and $x+n$
  - By the cohort person-years lived by women in the cohort between those ages

Formal definition of *ASFR*

- The abbreviation "*ASFR*" stands for age-specific fertility rate

- The cohort age-specific fertility rate (*ASFR*) ${}_nf_x$ is the number of children born by women in the cohort between ages x and $x+n$ per person-year lived by women in the cohort between ages x and $x+n$

Period age-specific fertility rate

- For a period age-specific fertility rate (${}_nF_x$)
  - We divide babies born to women aged x to $x+n$ in the period
  - By the period-person-years lived by women between those ages

Age groups for *ASFR*

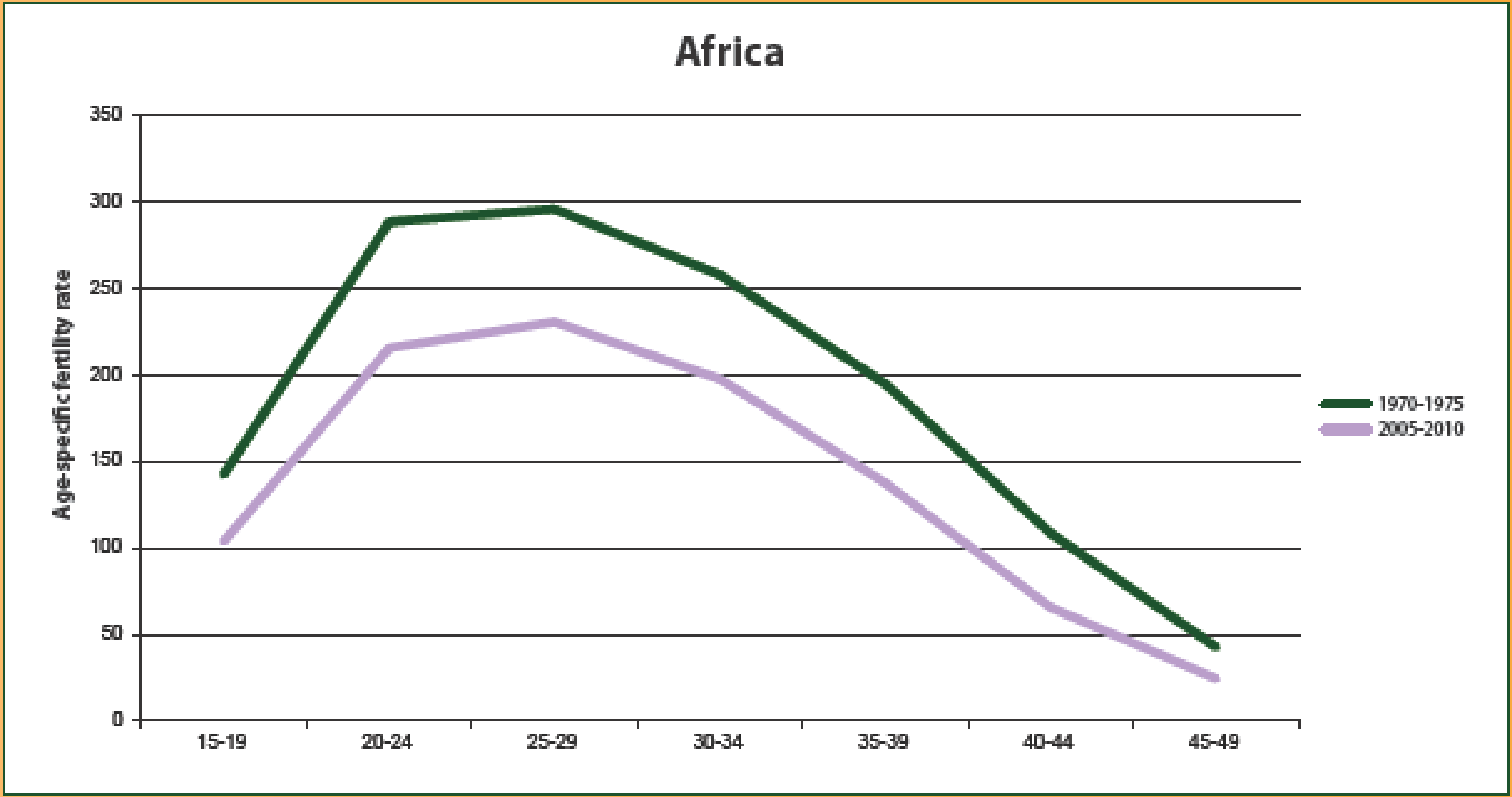
- Births rates of women according to their ages
- Usually calculated for women in each of the seven 5-year age groups
  - 15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49
  - Sometimes 35 single-year age groups are used
  - ${}_nASFR_x$ means *ASFR* for age group x to $x+n$

$${}_nASFR_x = {}_n\text{births}_x \,/\, {}_n\text{females}_x * 1{,}000$$

- Age curve of fertility: the seven plotted *ASFRs* usually have an inverted U shape

ASFR

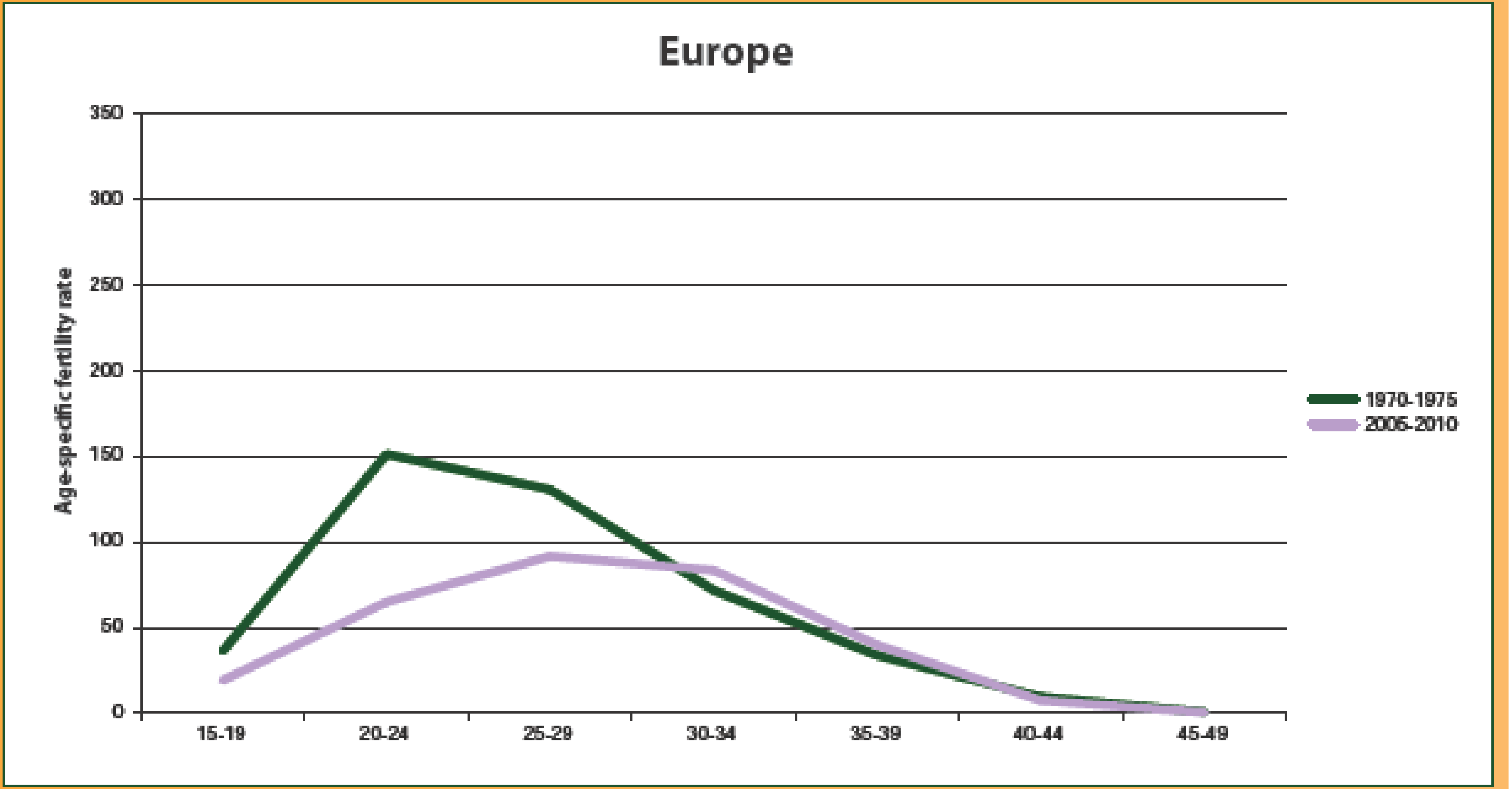
Age-specific Fertility Rates, Africa, 1970-75 and 2005-10



Source: United Nations, 2014a.

ASFR

Age-specific Fertility Rates, Europe, 1970-75 and 2005-10



Source: United Nations, 2014a.

Rates, not probabilities

- Age-specific fertility rates are rates, not probabilities
  - They have units of 1/time
- Babies are persons
  - So the babies in the numerator cancel the persons part of the person-years in the denominator, leaving 1/years
- Doubling the width of the age interval
  - It would increase both the numerator and the denominator and would not drastically change the rate

Analogy with mortality

- An age-specific fertility rate ${}_nf_x$ is the counterpart for fertility of the age-specific mortality rate ${}_nm_x$ in the lifetable

- ${}_nm_x$ has the same denominator but a numerator with deaths in place of births

Focus on female fertility

- It is usual to concentrate on age-specific fertility rates for women
  - Women's age is a more obvious determinant of fertility
- We can count births by age of father and divide by person-years-lived by men in the age interval
  - Such male *ASFRs* are rarely used
  - Ages of fatherhood are less narrowly restricted biologically and socially
  - Data on fathers' ages are rarely tabulated

Note on female fertility

- "Female" *ASFRs* pertain to female parents, but to both male and female babies
  - Sons and daughters enter into the numerator
  - Person-years for mothers into the denominator

- If the numerator is further restricted to daughters
  - The resulting rate should be labeled as a "daughters-only" *ASFR* (${}_nf_x^{\text{daughters}}$)
  - Or by multiplying ${}_nf_x$ by the fraction female at birth

Restrictions sometimes not clear

- Mathematical demographers often work with daughters-only rates

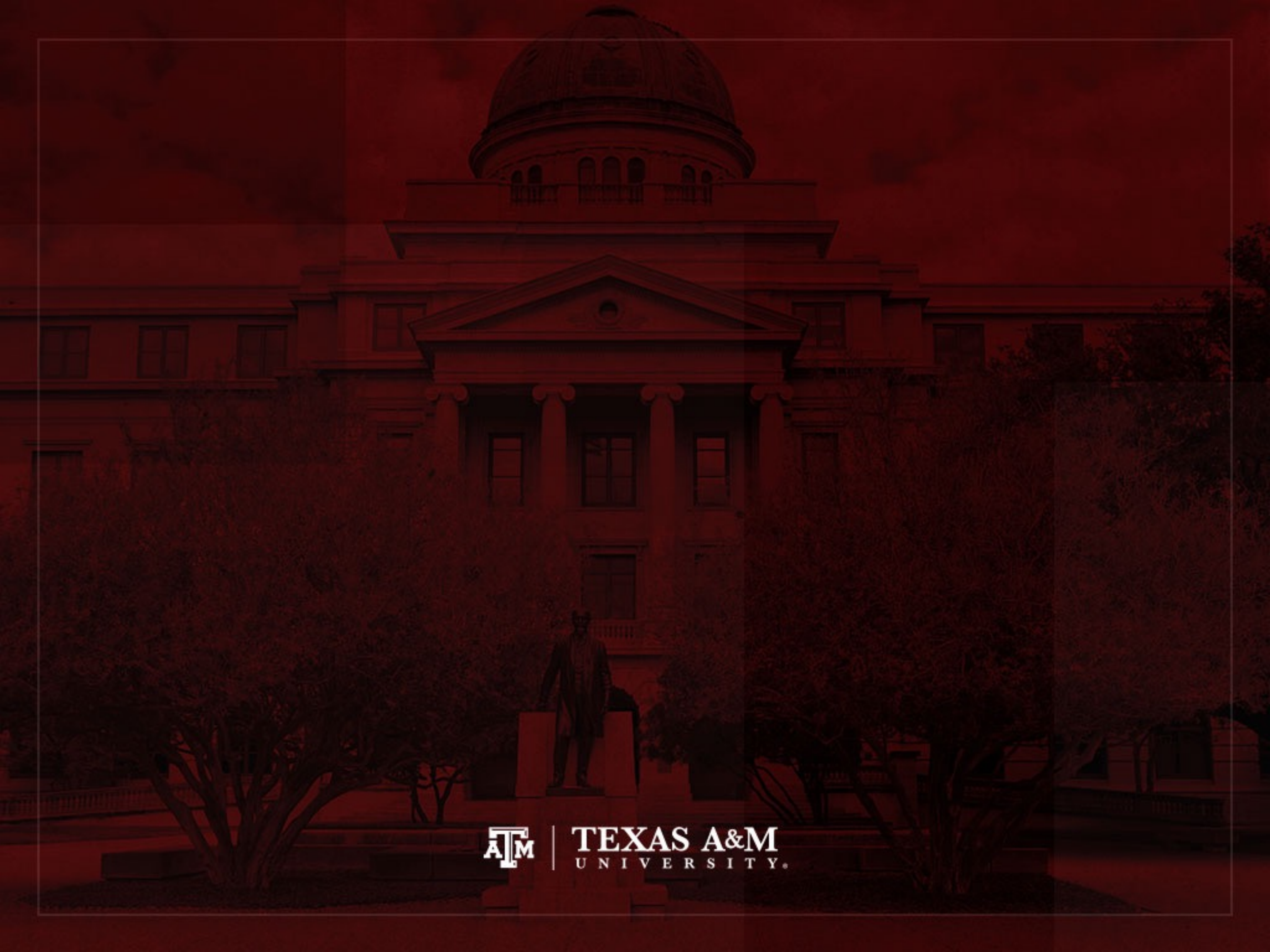
- Sometimes this restriction is mentioned in the text but omitted from the notation

Differentiating rates

$$Birth = \frac{Daughters + Sons}{Women + Men}$$

$$Fertility = \frac{Daughters + Sons}{Women}$$

$$Reproduction = \frac{Daughters}{Women}$$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ASFRs and the *NRR*

- A Net Reproduction Ratio is most often calculated from a table of age-specific fertility rates

- Later, we will be able calculate this ratio from period-based rates, as we do now with cohort-based rates

Steps to estimate *NRR*

- ${}_nf_x$ has babies divided by person-years
  - We need to multiply back by person-years to recover a count of babies
  - These are person-years lived by the female members of the cohort
  - We get them from the ${}_nL_x$ column of the female cohort lifetable

$$ {}_nf_x * {}_nL_x $$

Age-based formula for the *NRR*

- Need to add them up over all ages of childbearing
  - Σ (sigma) means add up over all the age intervals with different starting ages *x*
- Need to convert from babies to daughters
  - Multiply by f_{fab}
- Divide by the initial cohort size (l_0)

$$NRR = \sum {}_nf_x \, {}_nL_x \; f_{fab} / \ell_0$$

Example of *NRR* calculation

- Sample of 1,000 U.S. women randomly selected from the cohort born in 1934 (Table 4.2)
- Obtain the number of babies
  - Multiply the age-specific fertility rates (${}_nf_x$)
  - By the lifetable person-years lived (${}_nL_x$) (radix of 1,000)
- The sum of the column for babies is 3,063
- Multiply the sum by the fraction $f_{\text{fab}} = 0.4877$
- Divide by the radix

$$NRR = 3{,}063 \ast 0.4877 / 1000 = 1.494$$

Table 4.2 A cohort *NRR* from U.S. age-specific rates

x	${}_5f_x$	${}_5L_x$	Babies
0	0	4770	0
5	0	4726	0
10	0	4712	0
15	0.0811	4698	381
20	0.2384	4681	1116
25	0.1969	4662	918
30	0.1033	4637	479
35	0.0313	4604	144
40	0.0046	4561	21
45	0.0009	4503	4
			3,063

Two other measures of fertility

- Total Fertility Rate (*TFR*)
- Gross Reproduction Ratio (*GRR*)
  - They are usually calculated from period rather than cohort data
  - However, the concepts of the *TFR* and *GRR* are cohort concepts, just like the concept of the *NRR*
  - They are measures of fertility rather than generational renewal
- *TFR* and *GRR* exclude the effects of mortality
  - They indicate how many babies or daughters a cohort would produce in the absence of mortality

TFR and *GRR* formulas

- In the absence of mortality, each member of a cohort would live *n* person-years in the interval from *x* to *x*+*n*
  - Replace ${}_nL_x / l_0$ by n
- If we keep babies of both sexes, we get the *TFR*

$$TFR = \sum ({}_n f_x)(n)$$

- If we restrict to daughters by multiplying by the fraction female at birth (f_{fab}), we get the *GRR*

$$GRR = \sum ({}_n f_x)(n)(f_{\text{fab}})$$

Same *n* for all age intervals

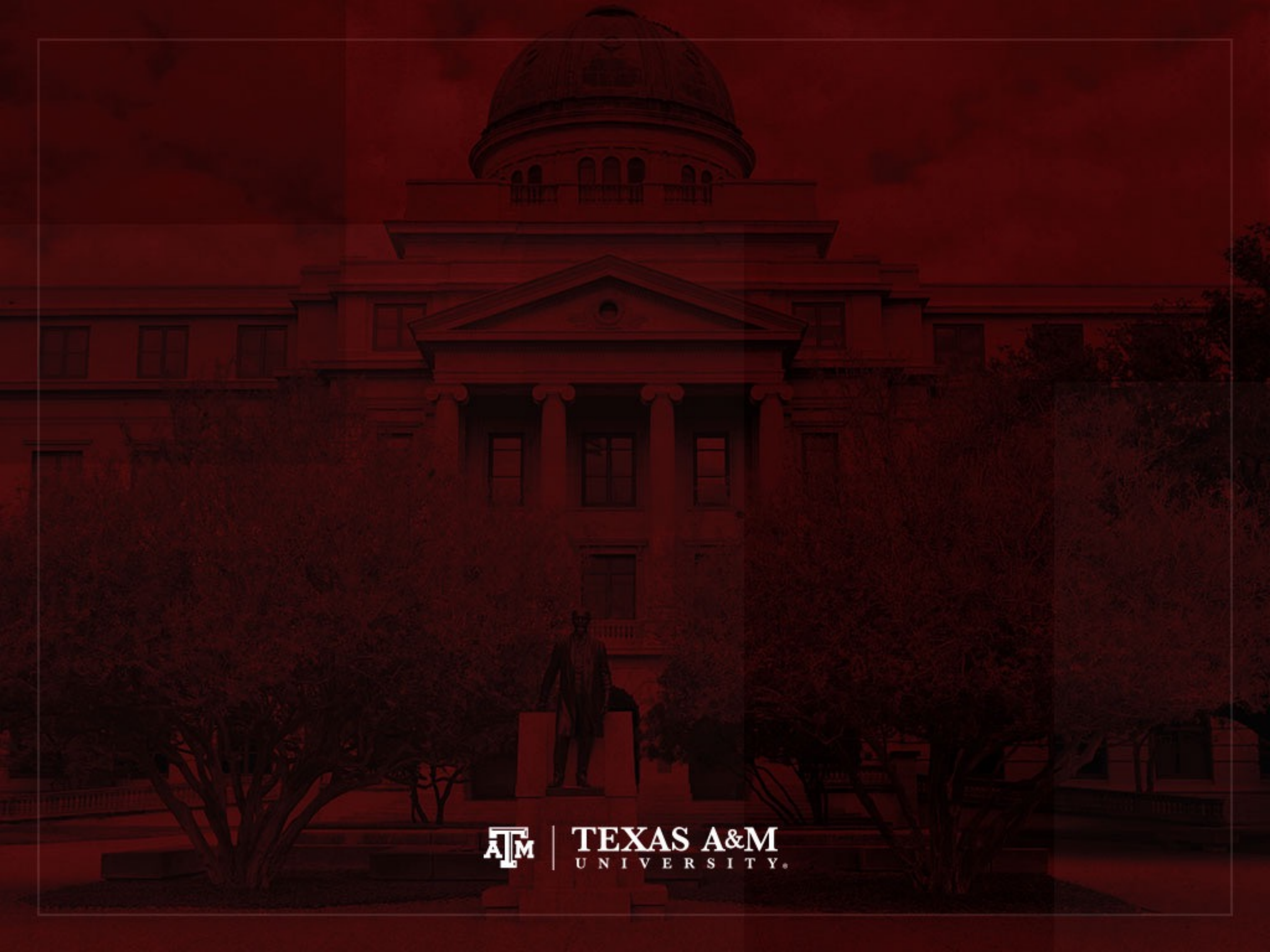
- When all the age intervals in a data table have the same width n

- We can add up the ${}_nf_x$ column and multiply by n at the end to obtain the *TFR*
  - From data in Table 4.2, *TFR* is 3.283

- Then we multiply by f_{fab} to obtain the *GRR*
  - From data in Table 4.2, *GRR* is 1.601

Some notes about *TFR*

- *TFR* is not the same as expected total of children for women who do live through childbearing ages
- Women who survive to 50 might not be a typical subset of all women
  - They might have had lower fertility in their twenties than women with poorer prospects for survival
- When we compute a *TFR*, we use the fertility for
  - All women in their twenties
  - Those who will and will not survive to older ages
  - Every age group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Cohort parity

- The discussed age-specific rates track childbearing across the lifecourse
  - As women in a cohort reach the end of their years of childbearing, we can estimate completed cohort fertility
- Data can come as distribution of children ever born
  - This allows a third way to calculate the *NRR*
  - The leading use for measures based on parity is the study of fertility limitation across history and around the world

Parity term

- Number of live births that a women has had is known as her parity
- “Parturition” means childbirth
- “Post partum” means “after childbirth”
- A woman is “nulliparous” when she has never had children

$w(j)$

- $w(j)$ is the count (tally) of women in a cohort who have parity j
- Parities are measured after all members of the cohort have completed childbearing
  - $w(0)$ cohort members have born no children
  - $w(1)$ have born one child
  - $w(2)$ have born two children

Estimate *NRR* with *w*(*j*)

- If we are given a tally of women by parity for a cohort, we can find the *NRR* by the following formula

$$NRR = \frac{(0 * w(0) + 1 * w(1) + 2 * w(2) + 3 * w(3)\ \ldots)(f_{\text{fab}})}{w(0) + w(1) + w(2) + w(3)\ \ldots}$$

  - Each woman at parity 1 contributes one child
  - Each woman at parity 2 contributes two children...
- Multiply by f_{fab} to convert from children to daughters and divide by initial cohort size

Example: *NRR* with cohort parity

- Completed parity for a sample of 1,000 women from the U.S. cohort born in 1934
  - $f_{fab} = 0.4877$

Table 4.3 Completed parity for U.S. women born in 1934

j	0	1	2	3	4	5	6	7	8	9	10
$w(j)$	76	97	233	241	166	90	47	30	12	5	3

$$NRR = (0*w(0) + ... + 10*w10)\ (f_{fab})\ /\ w(0) + ... + w(10)$$

$$NRR = (0*76 + 1*97 + 2*233 + ... + 10*3) * (0.4877)\ /\ 1{,}000$$

$$NRR = 1.494$$

Parity Progression Ratio: *PPR*(*j*)

- *PPR*(*j*): fraction of women in a cohort who, having reached parity *j*, go on to have another baby
  - They reach at least parity $j + 1$
  - End at some parity greater than *j*
- If *w*(*j*) women are ending up at parity *j*
  - $w(j) + w(j+1) + w(j+2)$... women reached at least parity *j*, ending up at parity *j* or more
  - $w(j+1) + w(j+2)$... of these women went on at least to parity $j+1$

Formula for *PPR*(*j*)

- The fraction progressing from *j* to *j*+1 is the ratio *PPR*(*j*) given by

$$PPR(j) = \frac{w(j+1) + w(j+2) + \ldots}{w(j) + w(j+1) + w(j+2)\ldots} = \sum_{j+1}^{\infty} w(i) / \sum_{j}^{\infty} w(i)$$

  - *PPR* is always labeled by the starting parity
  - In sigma notation, the starting index is written below the sigma symbol and the ending index above it
  - These sums go up to the highest parity observed, above which *w*(*i*)=0

Example: *PPR*(*j*)

Table 4.3 Completed parity for U.S. women born in 1934

j	0	1	2	3	4	5	6	7	8	9	10
$w(j)$	76	97	233	241	166	90	47	30	12	5	3

- *PPR*(0) = 924 / 1,000 = 0.924
  - All 1,000 women reach at least parity 0
  - 1,000 – 76 = 924 reach at least parity 1
  - This is the ratio that goes from 0 to 1
- *PPR*(1) = (924–97)/924 = 827/924 = 0.895
- *PPR*(2) = (827–233)/827 = 594/827 = 0.718

Data specificities

- Data in Table 4.3
  - Obtained by following girls born in 1934 as they grow, die or survive, and have children
  - This data considers cohort mortality
  - So we compute cohort *NRR*
- Other data might inform number of children ever born from women who have survived to a specific age (such as 50)
  - Mean completed parity for these surviving women would estimate cohort *TFR*
  - Multiplying by f_{fab} would estimate cohort *GRR* (not *NRR*)

Example: *PPR*(*j*), survivors data

- Parity for 50-year-old Dutch women in 2009
  - Survivors of the 1-year birth cohort from 1959

Table 4.4 Dutch women age 50 by parity, 2009

j:	0	1	2	3	4	5	6+
$w(j)$:	22,275	15,151	49,972	22,897	6,378	1,690	1,207
$j+$:	119,570	97,295	82,144	32,172	9,275	2,897	1,207
$PPR(j)$:	0.814	0.844	0.392	0.288	0.312	0.417	

Source: Human Fertility Database (HFD) (May 2013).

  - We know that $w(6+)=1{,}207$ and $w(5)=1{,}690$
    - Add up from the right to find the row for $j+$
    - 5+ women = 1,207 + 1,690 = 2,897
  - $PPR(5) = 1{,}207 / 2{,}897 = 0.417$
  - $PPR(0) = 97{,}295 / 119{,}570 = 0.814$

Trends of *PPR*(*j*)

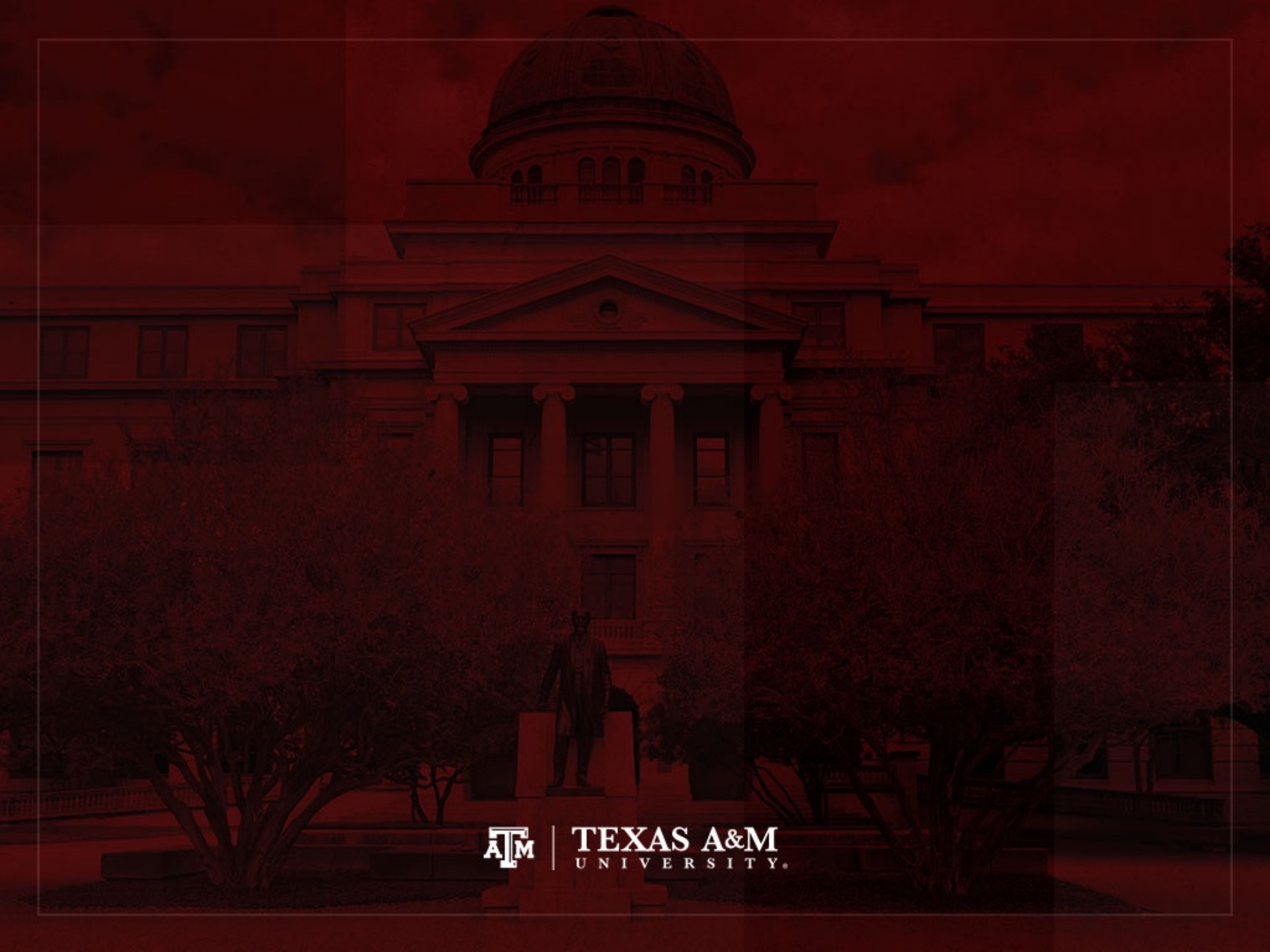
- In the example, PPR drops abruptly after *PPR*(1)
  - Many couples want no more than two children
- *PPR* increases at higher parities
  - Subset of women and spouses who want large families
  - Parities 5+ or 6+ are largely represented by them
- Some European countries are known for lowest-low fertility far below replacement levels
  - Whether fertility in these societies will rebound is a subject for lively debate

PPR for Malawi

- 2004 Demographic and Health Survey (DHS)
  - 770 women aged 45 to 50 interviewed
  - $PPR(0) = 0.978$
  - $PPR(1) = 0.976$
  - $PPR(2) = 0.940$
  - $PPR(9) > 0.600$
  - $PPR(11+) \approx 0.300$
- Sustained high *PPR* constitute evidence that family limitation practices are not widespread

Estimate *w*(*j*), based on *PPR*

- Example of Malawi: 770 women
  - Women who reach at least parity 1
    - Women 1+ = 770 * *PPR*(0) = 770 * 0.978 = 753
  - Women at parity 0
    - *w*(0) = 770 – 753 = 17
  - Women who reach at least parity 2
    - Women 2+ = 753 * *PPR*(1) = 753 * 0.976 = 735
  - Women at parity 1
    - *w*(1) = 753 – 735 = 18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Conscious fertility limitation

- Demographers have devoted sustained attention to develop measures to track fertility decline and conscious fertility limitation
  - Modern study of fertility limitation began with Louis Henry at the Institut National d'Études Démographiques (INED) in Paris
  - Extended by Peter Laslett, Anthony Wrigley, Rogers Schofield in the Cambridge Group for the History of Population and Social Structure in England
  - Continued at the Office for Population Research at Princeton University under Ansley Coale

Louis Henry

- To understand the onset of fertility limitation in a society, it was paramount to describe the pattern of fertility before these practices started
  - Conscious, intentional fertility limitation
  - Family planning
- Analyze data to distinguish between absence and presence of practices by which couples
  - Attempt to stop childbearing
  - After desired family-size targets have been achieved

Signs of fertility limitation

- Data on couples' intentions do not exist to any extent for previous centuries
  - Henry looked for signs that would appear in existing fertility data to indicate conscious family limitation
    - He focused on parity
    - Parity-specific control: when further childbearing is made to depend on the number of previous children
  - Leading signs of parity-specific control
    - Drop in Parity Progression Ratios at some parity
    - Whether age-specific fertility rates differ according to women's parities

Natural fertility

- Natural fertility is the fertility in the absence of parity-specific control

- Parity-specific control can be inferred from
  - Parity Progression Ratios
  - Fertility rates specific to parity and age

- We can use this information to measure whether fertility is "natural fertility" in Henry's sense

Numerator and denominator

- Each combination of age and parity specifies a group of women and an interval
  - e.g., women at parity 3 between ages 30 and 35
  - Numerator: births at parity 3 before age 35
    - Births at parity 3 move women to parity 4
  - Denominator: person-years lived at parity 3 between ages 30 and 35
- For marital fertility rate
  - Numerator only includes births to married women
  - Denominator only includes years lived while married

Example

- Age- and parity-specific fertility rates
  - Women between 30 and 35 years of age in 1990
  - Cohort born between 1955 and 1960

Table 4.5 Fertility rates specific for age and parity

Parity	0	1	2	3	4	5	6+
Nigeria	0.272	0.225	0.257	0.244	0.279	0.284	0.233
Netherlands	0.146	0.221	0.079	0.075	0.090	NA	NA

- At parity 0, 60 first births and 220.4 person-years over age 30
  - 60 / 220.4 = 0.272
- At parity 1, 101 second births from 448.2 person-years
  - 101 / 448.2 = 0.225

Interpretation of example

- For Nigeria, fertility rates for women of the same age are close to each other, regardless of parity
  - Evidence of natural fertility
  - Estimates subject to sampling error
- For Netherlands, fertility rates drop by nearly a factor of 3 from parity 1 to parities 2+
  - Few women at parities 5+ (not available estimates)
- This is a contrast between absence and presence of parity-specific control

Limitation of measures

- Parity Progression Ratios and fertility rates specific to parity and age
  - Supply evidence about deviations from natural fertility
  - Do not summarize the strength of fertility limitation

- Demographers use measures from period rather cohort rates to measure strength (chapter 6)

Family reconstitution

- Many of the innovative measures applied to contemporary populations were pioneered by historical demographers (Wringley et al. 1997)
  - Data from local records of baptisms, marriages, and burials from parish churches in England, France, and other European countries
  - Technique builds small family genealogies one by one
  - Estimate age-specific mortality and age- and parity-specific fertility
  - Data are incomplete due to migration

Biology perspective

- Biologists observe that differences in age-specific fertility rates between species are greater than within species
  - This perspective implies that levels of fertility for humans subject to natural fertility would be the same from person to person and society to society
  - Differences would appear with conscious fertility limitation
- Louis Henry discovered that this expectation is wrong

Biology, environment, culture

- If one takes natural fertility to mean the absence of parity-specific control
  - There are variations in level of fertility in human societies from time to time and place to place
- Biological and environmental factors affects fertility levels
  - Without introducing parity-specific patterns
  - These factors interact with different cultural practices
  - Not all forms of family limitation are parity specific

Technical distinctions

- Fecundity
  - Biological capacity for childbearing
- Fecundability
  - Probability of conceiving for a woman subject to a continuous exposure to the risk of pregnancy
- Fertility
  - Outcome level of childbearing
  - It depends on fecundity
  - It also depends on decisions and behaviors of couples within their social, cultural, and environmental context

Technical terms for infertility

- Primary sterility
  – Lack of capacity ever to have children, either for individuals or for couples
- Secondary sterility
  – Loss of capacity to have children, after some children have been born
- Post-partum amenorrhoea
  – Temporary infecundity for women following childbirth
- Lactational amenorrhoea
  – Temporary infecundity due to breastfeeding, which reduces when breast milk is replaced by other food

Variation in natural fertility

- Previous terms help explain reasons for various fertility levels in societies with natural fertility
  - Cultures have different norms about nursing and breast milk replacement
    - It affects lactational amenorrhoea
  - Post-partum abstinence varies by cultures
    - It does not depend on parity (not parity-specific control)
    - But it affects birth interval, infant survival, mother’s health
  - Nutrition affects fecundity in extremes of malnutrition
    - In famines, women stop ovulating
    - Unequal improvements in nutrition over the last centuries have been a major driver of economic development and indirectly of population growth

Homeostatic mechanisms

- Homeostatic mechanisms regulate population growth in relation to resources (Malthus)
  - Homeostatic means maintaining the same state
  - When resources are plentiful, growth rates rise
  - When resources are scarce, growth rates drop
- This process operates through mortality or fertility
  - Effects on fertility may operate through biological fecundity or through social practices
  - Main historical homeostatic mechanisms come from economic arrangements, culture, and social institutions

Proximate determinants

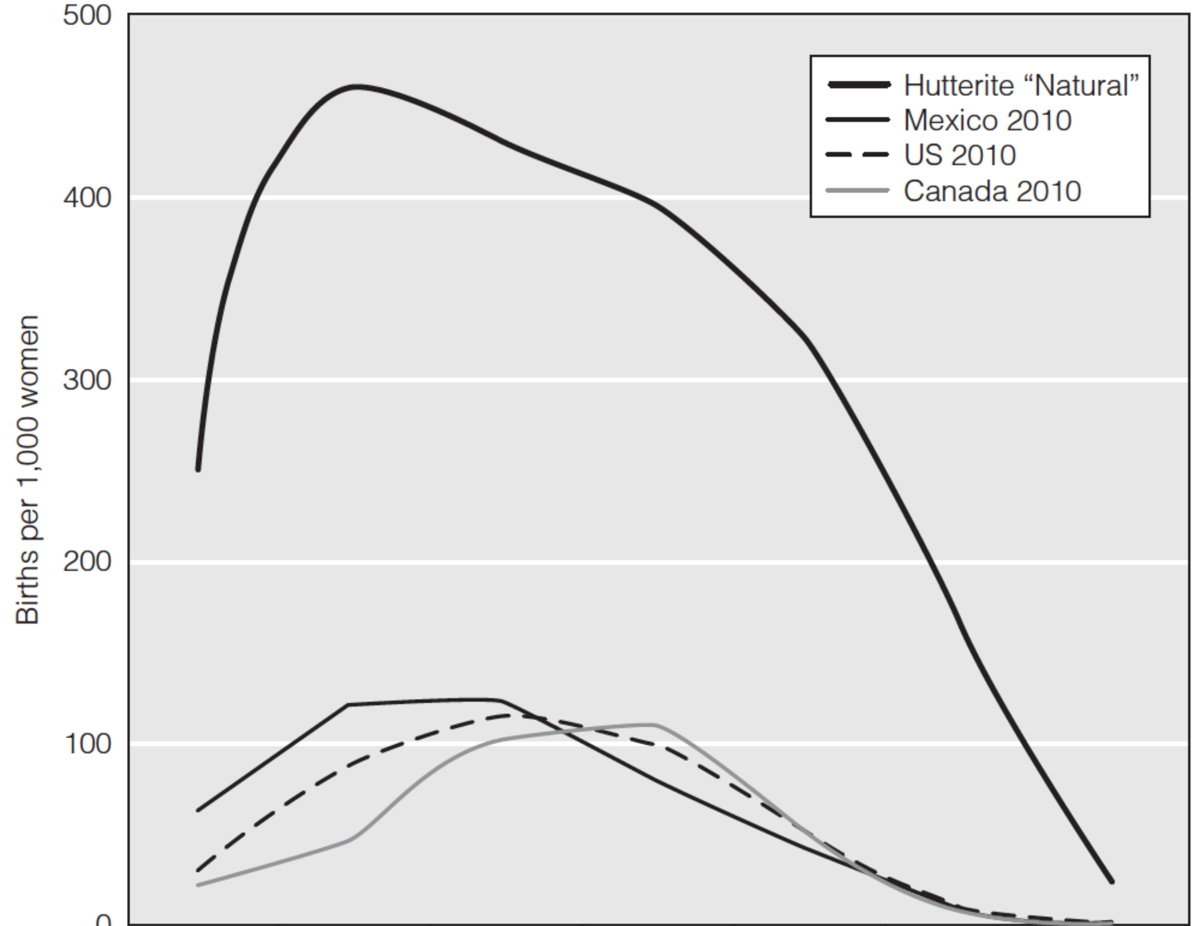
- Economic, social, and cultural factors do not themselves prevent births
  - Distinction between background causes and pathways that influence biological processes of having children
- The pathways are called proximate determinants
  - Proximate determinants are the nearest causal factors to the actual fertility outcomes that can be measured from ordinary demographic sources
    - i.e., surveys without special medical examinations
    - Examples: contraception, induced abortion, post-partum infecundity, marriage, sexual activity

Estimation of natural fertility

- Natural fertility (Henry 1961, Coale and Trussell 1974)
  - Level of reproduction in the absence of deliberate fertility control
  - Closer to 6 or 7 live births per woman
  - 25% of completed fertility is due to genetics (same as mortality)
- Hutterites had 11 children per woman (1930s)
  - Ethnoreligious group formed in the early 16th century
  - Early age at marriage, good diet, good medical care, regularly engage in intercourse without contraception or abortion
  - Nowadays, almost all live in South Dakota, North Dakota, Montana, and Western Canada

Source: Weeks, 2015.

Age-specific fertility rates

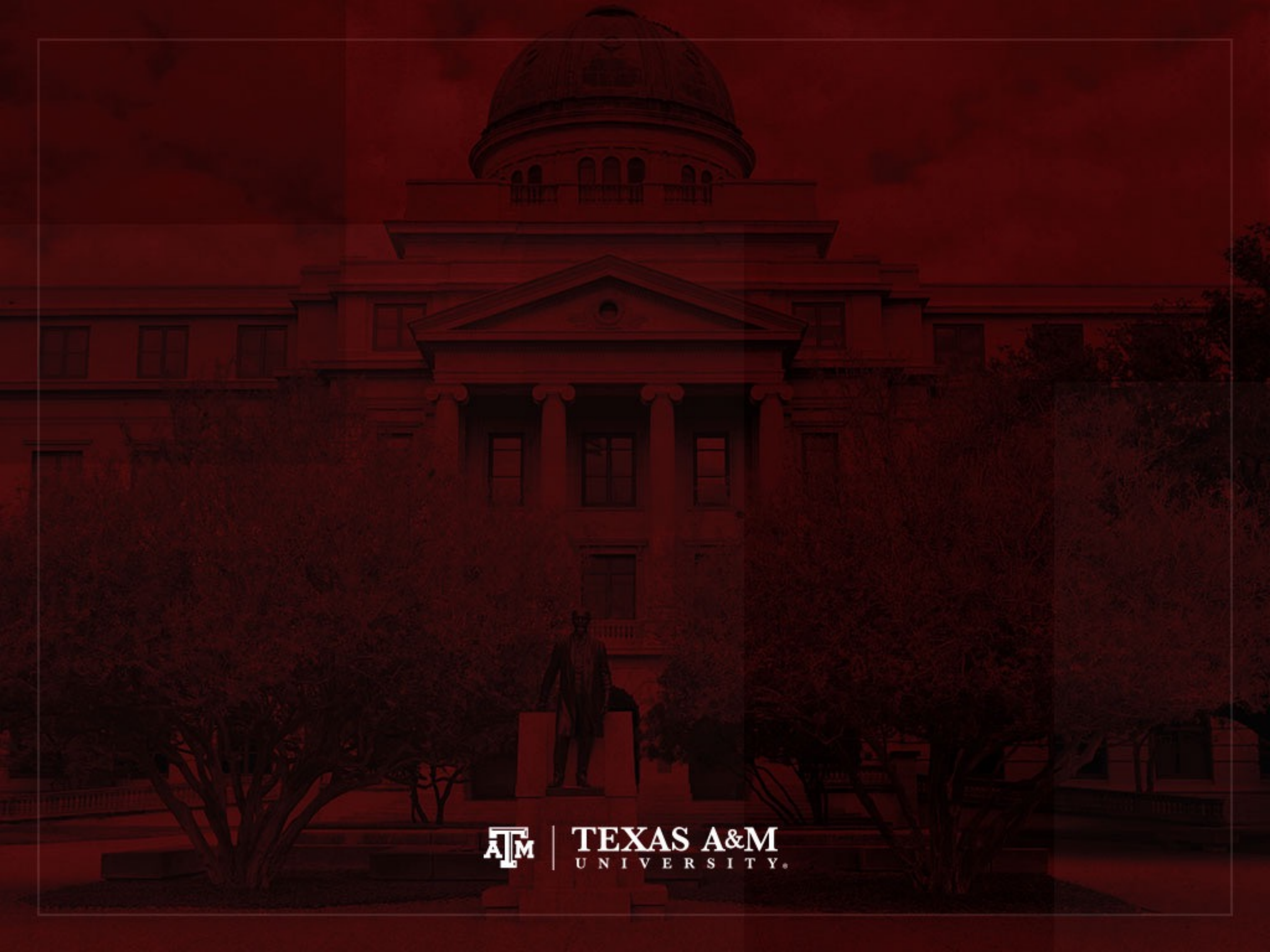


		15–19	20–24	25–29	30–34	35–39	40–44	45–49	TFR
1930	Hutterite "Natural"	250	460	431	396	321	167	24	11.0
	Mexico 2010	63	121	123	80	42	9	2	2.2
	US 2010	31	88	115	99	50	10	1	2.0
	Canada 2010	15	47	102	110	51	8	0	1.7

Source: Weeks, 2015.

References

Wachter KW. 2014. Essential Demographic Methods. Cambridge: Harvard University Press. Chapter 4 (pp. 79–97).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